

The Spectrum Policy Task Force Report reflects both an incredible opportunity and an incredible challenge.

The opportunity: The author strongly agrees that the exclusive use model, while suitable for some of the broadcast operations and limited device intelligence that characterized early radio applications, leads to very inefficient spectral utilization. The author also agrees that microprocessor control and software radio (flexible choice of modulation type) can greatly improve spectral utilization through use of opportunistic spectral access.

The challenge: Considerable work is necessary to (1) characterize existing spectral usage, (2) characterize interference susceptibility and explore ways to reduce susceptibility through improved processing, (3) develop means to reduce interference susceptibility by judicious choice of modulation type, and perhaps most importantly, (4) develop proactive system architectures and signalling protocols to facilitate opportunistic spectral access by allowing a user to indicate that he is being interfered with and to negotiate solutions to that interference. Note that item 4 is a complex and almost unexplored area. It is not sufficient for an opportunistic user to "listen," as is discussed below. Should the units register with a neutral third party database (maintained by whom?), or should they download a broadcast database (from whom?), or should they collaboratively negotiate (using what protocol?) an optimal (by what definition?) spectrum assignment?

Discussion: The Task Force points out (p.28) that "defining interference measures and setting them at an appropriate level will require the Commission to have a better grasp of the science involved prior to making rules and to anticipate better the consequence of different usages. This means that more engineers should be involved in the rulemaking process." The author wishes to point out that implementation of this approach will require studies, both empirical and analytical, to determine actual spectrum utilization as a function of frequency, geography, and modulation type. There is also the issue of interference susceptibility. Susceptibility would range from (1) the interference vulnerability of conventional modulation schemes (a new system might utilize a modulation specifically chosen to reduce this vulnerability!), to (2) the possibility of utilizing modulations which exhibit orthogonality or "interference resistance" to other modulations which are co-existing in the spectrum.

The Task Force also points out (p.33) that "The FCC could also allow 'opportunistic' devices to search across licensed spectrum and then to operate in licensed but unused spectrum without permission of the licensee, as long as those devices did not cause interference to incumbent licensees and instantly ceased transmitting whenever a licensee wished to use the spectrum." This is an excellent idea, but it implicitly requires that the opportunistic device must have a way of determining the interference that it is causing. The Task Force Report (p.34) states that "If opportunistic devices are to be authorized in the future, there will have to be regulations or protocols to ensure that they listen before they transmit and that they do not transmit when to do so would cause interference to an incumbent licensee." However, this is more easily stated than implemented. One could easily imagine a situation where users A, B and C are located along a straight line. User B is listening to a transmission from user A. User C cannot even detect user A, but his "opportunistic"

transmission might interfere completely with the ability of User B to hear User A. Even in simple broadcast cases, it can be shown that passive listening is not sufficient. The question becomes "how does an opportunistic licensee know that his transmission will not cause interference to an incumbent licensee?"

Prevention of this type of "jamming" requires the development and implementation of a signalling infrastructure so that user B [or a broadcast station] can indicate to user C that he is not free to transmit (and perhaps they can even "negotiate" a sharing protocol). The effectiveness of opportunistic systems will depend critically on the manner in which this interference "reporting" is implemented. How do you build the genie which controls spectral access? Centralized or distributed? Adaptive? Interactive? It is not currently clear whether there is any signalling or network control infrastructure that can meet the necessary requirements, or even what a well-designed set of requirements would be. Work needs to be done to (1) clarify the requirements, (2) provide existence proofs for effective signalling protocols, (3) develop system configurations that meet the requirements, (4) construct representative hardware and (5) implement a test program to validate (and iteratively improve) system performance. This work should be performed before any regulatory action to permit opportunistic transmission is taken.

The report contemplates (p.35) that "rights of licensed incumbent users should be limited to some extent to create "easements" for non-interfering uses below a defined interference temperature." The concept of interference temperature is a good one, but again, what counts is the interference at the location that is being interfered with, not at the location that is doing the transmitting. Again, this requires an active signalling infrastructure, since a transmitting device at one location must evaluate the interference that it is generating at another user's location. Similarly, page 35 states that "certain technologies should probably be allowed access to spectrum 'holes'," but how is a hole to be defined or determined? A way is required for a device to determine "permission."

Conclusion: The recommendations are exciting and "outside the box," but it is important to assess the interference issues, access control methodologies, potential improvement to be gained, and appropriate policy structure, that are necessary to implement and regulate this new type of access. A better understanding of these factors should both precede and guide the drafting of policy changes.

Respectfully submitted,

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